CLAIMS

I CLAIM:

1. A method of investigating a sample comprised of a sequence of at least one layer of material, each said layer having a thicknesses on the order of less than about 100 Angstroms, said method comprising the steps of:

a) providing two samples, at least one of which comprises at least one thin layer of material thereon;

b) obtaining spectroscopic data for each of the samples by causing polychromatic electromagnetic radiation to interact with each said sample and then enter a detector to the end that spectra for both samples are provided;

c) subtracting the obtained spectra from one another;

d) determining differences in said spectra; and

e) analyzing said differences in the spectra.

2. A method of investigating a sample comprised of a sequence of high and low "K" dielectric constant layers of material which each have thicknesses on the order of less than about 100 Angstroms each comprising the steps of:

a) providing two samples, at least one of which comprises a sequence of high and low "K" dielectric constant layers;

b) obtaining spectroscopic data for each of the samples by causing polychromatic electromagnetic radiation to interact

with each said sample and then enter a detector to the end that spectra for both samples are provided;

c) subtracting the obtained spectra from one another;

d) determining differences in said spectra; and

e) analyzing said differences in the spectra.

3. A method as in Claim 2, in which one sample is without an intentional sequence of high and low "K" layers present thereupon, and the second of which has a sequence of high and low "K" layers present thereupon.

4. A method as in Claim 3, in which one sample is bulk material with minimal native oxide layer.

5. A method as in Claim 2, in which both samples have a sequence of high and low "K" layers present thereupon.

6. A method as in Claim 5, in which both samples are meant to have the same fabricated structure, and in which the difference of the spectroscopic spectra indicates an undesirable difference in the fabrication process.

7. A method as in Claim 5, in which both samples are meant to have different fabricated structure, and in which the difference of the spectroscopic spectra indicates a desired difference in the fabrication process.

8. A method of tracking fabrication of a sample comprising a sequence of high and low "K" dielectric constant layers of materials which each have thickness on the order of less than 100 Angstroms comprising the steps of:

a) fabricating a reference sample which comprises a sequence of high and low "K" dielectric constant layers;

b) obtaining spectroscopic data therefrom as said reference sample is fabricated;

c) fabricating a second sample which is meant to be the same as the reference sample

d) obtaining spectroscopic data therefrom as said second sample is fabricated and in real time detecting differencs said spectra as compared to the corresponding reference sample spectroscopic data; and

e) modifying fabrication parameters to minimize said differences.

9. A method as in Claim 8 in which the spectroscopic data for each of the two samples is ellipsometric PSI and/or DELTA vs. wavelength.

10. A method as in Claim 8 in which the spectroscopic data for each of the two samples is derived from ellipsometric PSI and/or DELTA vs. wavelength, and comprises a difference in at least one selection from the group consisting of:

$$N = \mathrm{Cos}(2\Psi);$$
$$C = \mathrm{Sin}(2\Psi)\mathrm{Cos}(\Delta);$$
$$S = \mathrm{Sin}(2\Psi)\mathrm{Sin}(\Delta);$$

calculated for each of the two samples.

11. A method as in Claim 8 in which the spectroscopic data

for each of the two samples is derived from ellipsometric PSI and/or DELTA vs. wavelength, and comprises a difference in an RMS value calculated from:

$$\sqrt{\frac{(N_f - N_0)^2 + (C_f - C_0)^2 + (S_f - S_0)}{3}}$$

where:

$$N_1 = \text{Cos}(2\Psi);$$
$$C_1 = \text{Sin}(2\Psi)\text{Cos}(\Delta);$$
$$S_1 = \text{Sin}(2\Psi)\text{Sin}(\Delta);$$

correspond to one of said samples and:

$$N_2 = \text{Cos}(2\Psi);$$
$$C_2 = \text{Sin}(2\Psi)\text{Cos}(\Delta);$$
$$S_2 = \text{Sin}(2\Psi)\text{Sin}(\Delta);$$

corresponds to the second sample.

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~~11~~ 12. A method as in Claim 8 in which the layers of a sample which has a sequence of high and low "K" layers present thereupon includes layers comprised of at least one selection from the group consisting of:

SiO_2;
SiON;
HfO;
HfO-SiO_2.

13 ~~12~~. A method as in Claim . 8 in which the electromagnetic radiation comprises wavelengths in at least one selection from the group consisting of:

FIR;
IR;
NIR-VIS-NUV;
UV;
DUV; and
VUV.

14 ~~13~~. A method for evaluating thickness of an ultrathin film comprising the steps of:

a) providing a system comprising an optically absorbing substrate with a layer of optically transparent material on a surface thereof which is greater than about 250 Angstroms deep;

b) causing a beam of spectroscopic electromagnetic radiation to impinge on said surface of said optically transparent material at an oblique angle, interact with said system and via a detector determining spectroscopic ellipsometic PSI (Ψ) and DELTA (Δ), and therefrom calculating at least one selection from the group consisting of:

$$N_o = \cos(2\Psi);$$
$$C_o = \sin(2\Psi)\cos(\Delta);$$
$$S_o = \sin(2\Psi)\sin(\Delta);$$

c) depositing an ultrathin film of absorbing material on a surface of said layer of optically transparent material and again causing a beam of spectroscopic electromagnetic radiation to impinge on said surface of said optically transparent material at an oblique angle, interact with said system and via a detector obtaining spectroscopic ellipsometic PSI (Ψ) and DELTA (Δ), and therefrom calculating at least one selection from the group consisting of:

$$N_f = \mathrm{Cos}(2\Psi);$$
$$C_f = \mathrm{Sin}(2\Psi)\mathrm{Cos}(\Delta);$$
$$S_f = \mathrm{Sin}(2\Psi)\mathrm{Sin}(\Delta);$$

d) over a spectroscopic range of wavelengths determining a parameter vs. wavelength which depends on at least one difference selected from the group consisting of:

$$(N_f - N_o);$$
$$(C_f - C_o); \text{ and}$$
$$(S_f - S_o);$$

e) using peaks in the parameter determined in step d to evaluate thickness of the ultrathin film.

~~14.~~ 15. A method for evaluating thickness of an ultrathin film as in Claim ~~13~~ 14, in which the parameter determined in step d is an RMS value calculated from:

$$\sqrt{\frac{(N_f - N_0)^2 + (C_f - C_0)^2 + (S_f - S_0)}{3}}$$

~~15~~ 16. A method for evaluating thickness of an ultrathin film as in Claim ~~13~~ 14, in which the depth of the layer of optically transparent material is 1000 Angstroms or greater.

~~16~~ 17. A method for evaluating thickness of an ultrathin film as in Claim ~~13~~ 14, in which the depth of the layer of optically transparent material is 1000 Angstroms or greater and in which the parameter determined in step d is an RMS value calculated from:

$$\sqrt{\frac{(N_f - N_0)^2 + (C_f - C_0)^2 + (S_f - S_0)}{3}}$$

~~17~~ 18. A method for evaluating thickness of an ultrathin film as in Claim ~~13~~ 14, in which optcal constants of the ultrathin film of absorbing material on a surface of said layer of optically transparent material, are also determined.